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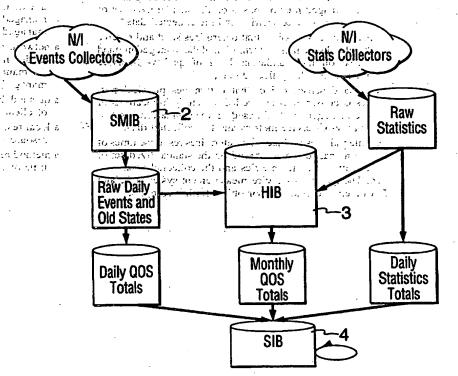


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(21) International Application Number: (22) International Filing Date: (30) Priority Data: 2,200,009 14 March 1997 (14.03.97) 2,200,011 60/043,080 8 April 1997 (08.04.97) (71) Applicant (for all designated States except US): CROS SYSTEMS CORPORATION [CA/CA]; 350 Ten Drive, Kanata, Ontario K2K 2W5 (CA). (72) Inventors; and (75) Inventors/Applicants (for US only): FORGET, Leo [CA/CA]; 13 Riding Way, Ontario K2M 1C3 (CA). (74) Agent: MITCHELL, Richard, J.; Marks & Clerk, P. 957, Station B, Ottawa, Ontario K1P 5S7 (CA).	LC, LK, LR, LS, LT, LU, LV, MD, MG, MX, NO, NZ, PL, PT, RO, RU, SD, SE, TJ, TM, TR, TT, UA, UG, US, UZ, VN, Patent (GH, GM, KE, LS, MW, SD, SZ, UG, patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, patent (AT, BE, CH, DE, DK, ES, FI, FR, LU, MC, NL, PT, SE), OAPI patent (BF, CM, GA, GN, ML, MR, NE, SN, TD, TG, TG, TG, TG, TG, TG, TG, TG, TG, TG	ES, FI, GB, GIG, KP, KR, KZ, MK, MN, MW, SG, SI, SK, SI, CU, ZW, ARIPG, ZW), Eurasia, TM), Europea GB, GR, IE, IT, BJ, CF, CG, Co.
direct. dir	ENT IN DATA NETWORKS	

(57) Abstract

A method managing a telecommunications network which involves maintaining a database containing data relating to service level agreements with customers using an object model. Data from the network data relating to the performance of the network is continually compared with data stored in the database. A report is generated based on this data showing the performance levels for individual customers in meeting commitments stored in the database containing data relating to the service level agreements.



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SERVICE LEVEL AGREEMENT MANAGEMENT IN DATA NETWORKS

The present invention relates to a method of managing a telecommunications network, and in particular to a method of monitoring the compliance with service level agreements.

More and more telecommunications services are now becoming available to the consumer. In packet switched networks, unlike circuit switched networks, customers are not given a dedicated circuit; their data is statistically multiplexed with data from other sources. Each customer pays for a particular level of service, and it is therefore important to ensure that the customer is receiving the level of service he has paid for.

There is a thus need for a system that manages service level agreements (SLAs) between telecommunications service providers and their business customers. Part of the management process that relates to SLAs is the comparison of the service providers' performance vis-à-vis specific guarantees that it may provide to its customer. Such a system must be capable of handling vast amounts of data.

A object of the invention is to provide such a system.

According to the present invention there is provided a method managing a telecommunications network comprising the steps of maintaining a database containing data relating to service level agreements with customers using an object model, receiving from the network data relating to the performance of the network, comparing the data received from the network with data stored in said database, and generating a report based on said data showing the performance levels for individual customers in meeting commitments stored in said database containing data relating to service level agreements.

The method may be implemented, for example, on a Sun Sparc Ultra 2 Unix-based workstation and, for example, work in conjunction with a Newbridge Networks Corporation 46020 network manager.

In a preferred embodiment the event is generated when the discrepancy between sperformance levels and commitments exceed a predetermined threshold value.

As a specific example, consider a case where the service provider guarantees a

Cell Loss Ratio of a specific percentage for an ATM (Assynchronous Transfer Mode)

30 p PVC service. This ratio is guaranteed over a monthly period. A PVC (permanent virtual circuit) is a logical circuit between two points used to carry bi-directional information.

The Cell Loss Ratio indicates the quality of a specific service by providing a

reasons such as network congestion and network failure. The Cell Loss Ratio for an ATM

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35 PVC based service is calculated using the following formula:

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CLR =
$$((\sum Ra + \sum Rz) - (\sum Ta + \sum Tz))/(\sum Ra + \sum Rz) * 100$$

where CLR = Cell Loss Ratio and the control of the

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Ra = number of data cells received by the provider's network from side A

Rz = number of data cells received by the provider's network from side Z

Ta = number of data cells transmitted by the service provider to side A

Tz = number of data cells transmitted by the service provider to side Z.

Data which relates to Ra, Rz, Ta, and Tz is typically available from the ATM switching equipment in the form of statistical counters that are regenerated every fifteen minutes. Various other statistics, provided by the ATM switching equipment, are required for the verification of other service quality metrics.

These statistical counters must be collected by a management system in order to aggregate and summarize the various quality metrics associated with each service. This involves storing and managing millions of statistical counters that are required to manage the services offered by a typical service provider. In order to gain a better perspective as to the magnitude of this need, let's consider the following typical example.

A service provider must measure service performance metrics on 50,000 PVC services. Each PVC service generates 2 statistical reports per 15 minute interval (1 for each side of the PVC). Each statistical report consists of an identifier, a time stamp, and 8 statistical counters. Thus in this scenario, the management system must process 9.6 million records (50,000*2*96 intervals). Furthermore, raw statistical information must typically be available on-line for up to 60 days. Thus the system must manage (9.6 * 60) 576 million records or 54 gigabytes of storage space.

the table (576 million records), it must be indexed or searches in this table would be cumbersome and time consuming. Conversely, the processing to add 9.6 million records to an indexed table of 576 million records would take days, as the amount of time 25 required to load data into an indexed table grows exponentially with respect to the volume of data already in the table.

The difficulty is how to manage effectively and efficiently this vast quantity of data that changes rapidly in real-time. This is quite a daunting task.

In a preferred embodiment, a plurality of working table fragments forming part of a fragmented table are created in memory, data is loaded in successive predetermined time periods into successive table fragments in a predetermined sequence, and the data are processed separately when loaded into the table fragments.

The data are preferably loaded into said table fragments using a round robin table in the fragmentation strategy.

35 and The invention also provides a telecommunications network service level manager comprising a database containing data relating to service level agreements with customers using an object model; means for receiving from the network data relating to the

performance of the network; means for continually comparing the data received from the network with data stored in said database, and means for generating a report based on said data-showing the performance levels for individual customers in meeting commitments stored in said database containing data relating to said service level agreements.

The invention still further provides a method of controlling a computer in an object-oriented environment wherein descriptors implemented as an object oriented class are used to store meta information on other classes in the system.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:

- Figure 1 is a software architecture diagram of a system in accordance with the invention;
 - Figure 2 is a data flow diagram;
 - Figure 3 is a database entity relationship diagram for the object model;
 - Figure 4 shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the SMIB; and the shows the entities contained in the shows the entities of the shows the entities of the shows the shows the entities of the shows the sho
 - Figure 5 shows the entities contained in the HIB;
- Figure 6 shows the entities contained in the SIB; 15
 - Figure 7 is a software Architecture Diagram showing daily data process flow;
 - Figure 8 shows the system table fragmentation strategy;
- Figure 9 shows a fragmented HIB table and related entries in the DBSpace usage table in the SMIB: 10 to a read to eval to be quite and use of the end of the great
 - 20 Figure 10 illustrates the identifying and detaching aged data in a HIB table;
- Figure 11 illustrates the attaching of new data to a table in a HIB and updating the
- tell and Dospeace usage table in the SMIB; and the street of the Hillion Circ. Tell and
- Figure 12 shows combinations of start and completion times of states, caused by events in to not independ out of a million records would take demonstrate a fine administration of the second taken and the second taken and the second taken as the second take
- Figure 13 shows the object models for a telcom information management architecture; Figure 14 illustrates the different types of descriptors that are employed in the system;
 - Figure 15: shows the top-layer-object-modeling of west silvetuorists of a
 - Figure 16 shows the admin entity in Figure 13 and wibiter some to and such
- Figure 17 shows the service layer object model of Figure 13.
- 30 As will be apparent from the following description, the invention implements an object model to efficiently construct the management system capable of handling a large volume of information. Referring now to Figure 1, Database Monitor (ckdbmon) 1 exchanges messages with the system databases, namely the service management information database (SMIB) 2, the historical information database (HIB)3, summarized information
 - 35. database (SIB) 4, and Network Interface Systems Director (the Keep Alive Process) 5.

things and joint model in early for secepting that it is not higher that has reading to the

The ckdbmon lidoes not interface directly with the system databases, but with a relational

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database management system (RDBMS) 7 employed by the system, namely Informix The world of the wife of the contraction of Online version 7.13.

The Monthly Frame Relay and ATM Statistics are derived from the Daily Frame Relay and ATM summarizations already contained in the SIB 4. This is indicated in Figure 2 with the asterisk (*). Figure 3 illustrates the process flow of this data as it relates to the daily processing of the system Data. or whom submitted the water to provide

The Data Management Framework consists of a database monitoring tool, load and unload utilities, and several scripts that employ the load and unload utilities in order to migrate and summarize data between the various databases. The monitoring component utilizes the Network Interface keep alive process and the monitoring tool's output is logged in a Network Interface Logging Tool compatible format 8. The advantages of doing so are that the logging interface is common between the database and network interface frameworks, and the ability to reuse coded and tested tools is provided.

The load and unload utilities also use the log tool format to post all operational and alert messages, as do the utility scripts.

The role of the monitoring tool bis to ensure that the system databases do not exceed predefined space utilization thresholds, that the System databases remain active and available to the end users, and that the Informix Online specific event log file (typically called online log) does not grow too large. Should Sections of the System databases become too full (exceeding the threshold), a message is posted, via the log tool, to the

drSystem Administrator (not shown)! East to be young to the co

If; for some reason, the System databases are in an unavailable state (due to Informix Online being brought off-line), the monitor 1 will make several attempts to restart Informix Online and will again post an afert to the System Administrator stating that Informix Online is off-line and it (the monitor) is attempting to restart it.

When the Informix specific event log file exceeds the predefined size that the monitor is gauging it against, the monitor 1 will remove log file entries (checkpoint notification messages only), starting with the oldest ones, until the log file again fits within a specified Coursen size range.

These monitoring functions provide the System Administrator with more freedom, as less 30 manual checking of the System Databases status is necessary: Additionally, the monitor promotes greater System database availability as the most common database operationstopping difficulty, namely running out of space, is monitored and alerts are sent in anticipation of a problem occurring, not just in response to one.

The Director 5 (the Network Interface keep alive process) ensures that the database 35 monitor (ckdbmon) 1 is started and remains active. The ckdbmon, in turn, ensures that the database management system 7 (Informix Online) remains active. Ckdbmon 1 will

	shutdown gracefully, if it receives a shutdow	n command from the Director 5. However	r
	ckdbmon will not shut down Informix Online	e when the Director's shutdown message	is
1 - 3.	received, and the second state of the second		
	Informix may only be brought off-line by the	Administrator explicitly issuing the valid	i
5	Informix commands (onmode -uy; followed b		
	Director's shutdown commands, and cannot l	_	
÷	System databases may remain on-line, and av		
. 1.		-	
•	Figure 3. illustrates an example of an object m		
10	Figure 3, the object entities are defined as fol	•	-
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Child of: Customer via Customer id number, Contract via Contract id number, Service Profile via Service Profile id number.

Historical Service

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A service is anything that the service provider determines that customers wish to purchase and that the service provider is willing to supply. A Historical Service record contains information that was current until the associated customer, contract, or service profile changed.

Child of: Customer via Customer id number, Contract via Contract id number, Service Profile via Service Profile id number.

Contact

A Contact unambiguously identifies a person who carries out a role associated with a specific service entity (Customer, Contract, Current Service).

Child of: Customer, Contract, Current Service via service entity id number, Person via Person id number.

Service Component

A service component is any network entity that is used within a service offered to a customer. Each service can consist of one or more service components. At the time of the network entity creation, the service component will not be related to any service. It may be assigned to a service at a later time.

Parent to: Frame Relay PVC, Frame Relay CTP, ATM PVC, ATM CTP, TDM Circuit, TDM NI, Service Information, Events, Current State, Old State via Service Component id number.

Child of: Current Service via Service id number.

Service Profile

A service profile describes the characteristics of a specific service or group of services.

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Parent to: Current Service, Historical Service, Valid Service Component, Service Profile Threshold via Service Profile id number.

Valid Service Components

A description of each Valid Service Component that can be associated with a Service Profile.

Child of: Service Profile via Service Profile id number.

Service Profile Threshold

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man redmin Service Profile Thresholds are SLA thresholds that are associated with a Service Profile.

Child of: Service Profile via Service Profile id number.

Administrative Entities

attended to the break of the contract of the breaking of the contract of the breaking of the contract of the c

A role identifies all the actions, with respect to the System, that a user in a specific job function is permitted to perform.

Parent to: User, Entity Access via Role id number.

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10 The state of User of the state of the sta

A user is a communicating entity which is registered in the Resolve Databases for the purpose of performing tasks with the Resolve

Parent to: Audit Entry via User id number. Additionally, all creation of and modifications to Customers, Contracts, Current Services, Historical Services, Service Profiles, Network Entities (PVC's, CTP's, NI, etc.), Roles, Persons can be performed by Limited to the control of the existing User ids only.

Child of: Person via Person id number, Role via Role id number.

was a firm and the state

อเทียวรับที่ เป็นสภามตรงขายของ จ. จารยอด ท A person is a specific individual. All Contacts must be Persons. All Users must be Persons.

Parent to: Contact, User via Person id number.

THE TEAT OF THE PROPERTY OF TH

An audit entry is generated each time user performs an operation. This entry contains references to the user, the action performed, the type of entity operated on, and the time the operation occurred. Child of: User via User id number, Valid Entity Operations via Entity/Operation number.

30 Entity Access Control Inortal colons of

This entity is used to define what operations, on what entity, are permitted for a given role. One instance of this record is created for each entity to which a specific role has privileges on.

Child of Role via Role id number, Valid Entity Operations via

Valid Entity Operations

Similaril'I diserte da de 12

This entity is used to define valid operation and entity combinations for the Resolve System. These combinations are then and to create Audit orthine CTP's information.

540 A. A. C. Parent to: Audit Entry, Entity Access Control via Entity/Operation number.

Network Entities and the difference as company

Committee Committee Committee

The FR PVC has no mer for marina specification

Frame Relay Permanent Virtual Circuit.

Parent to: FR'NP, FR CTP via Network Entity id number. Child of: Service Component via Network Entity id number.

FRICTP. AND MAY BE TO STANK WAY

Frame Relay Circuit Termination Point. A FR PVC will have two or more (two in this release) Termination Points. Future services, such as multicast connections will have multiple CTP's.

and the standard of the Child of: FR PVC, Service Component via Circuit id number.

recut . . .

FR NP

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Frame Relay Network Performance. This entity consists of network performance statistics collected from each FR PVC path end.

Parent to: FR PV@ Daily NP, FR PVC Monthly NP via FR PVC id minimber, and Path End id number.

Child of: FR PVC via FR PVC id number.

FR PVC Daily NPprixalqui. M robivid smill

FR PVC Daily Network Performance. Daily summarization of FR 25-dama L. Cond drown of PVC Network Performance. 11.10

Child of: FR NP via FR PVC id number, and Path End id number.

FRPVC Monthly NPosici land merelvice again

and any of the state of the FR Monthly Network Performance. Monthly summarization of FR PVC Network Performance

Child of: FR NP via FR PVC id number, and Path End id number. An Everalis indicated a describing an once conduction for non-

ATM PVC issimper of magery, apid wholl office

Asynchronous Transfer Mode Permanent Virtual Circuit.

The ATM CTP via Network Entity id number.

Child of: Service Component via Network Entity id number.

ATM CTP

Asynchronous Transfer Mode Circuit Termination Point. An ATM PVC will have two or more (two in this release) Termination . i. . Points, Future services, such as multicast connections will have multiple CTP's. MULLI TO Child of: ATM PVC, Service Component via Circuit id number. 1:1: 5.1. 45. Commence to the commence of ATM NP 3.42.20 Asynchronous Transfer Mode Network Performance. This entity consists of network performance statistics collected from each ATM PVC path end. as are made 10 Parent to: ATM PVC Daily NP, ATM PVC Monthly NP via ATM PVC id number, and Path End id number. Child of: ATM PVC via ATM PVC id number. ATM PVC Daily Network Performance. Daily summarization of 15 - 9 m ATM PVC Network Performance. Child of: ATM NP via ATM PVC id number, and Path End id number. ATM PVC Monthly NP (1997) 1997 1997 ATM Monthly Network Performance. Monthly summarization of ATM PVC Network Performance. Child of FR NP via FR PVC id number, and Path End id number. C" LANDER FOR HER BOOK TO THE TOTAL TO THE TOTAL TO THE TOTAL TO THE TOTAL TOT Time Division Multiplexing Circuits 7. 11. 1971. History is the many the last the parent to: TDM: Ni via Network Entity id number. Child of: Service Component via Network Entity id number. 25 CHIEF OF THE REVENUE OF THE BOOK OF THE BO Time Division Multiplexing Network Interface. Child of TDM Circuit; Service Component via TDM Circuit id number arriors a Province N. D. 49. Card of EX NP was R PVC if all wheat they be to the OVE at the Wind An Event is information describing an occurrence on the network entity for which a report is required. 5970 3,1977 The State of State of Event id number. and district the Harry west of Children Service Component via Network Entity id number. 35 anare him Current State, in premount of the chief? ATO WEST

The Current State of each Service Component is described. The Event id number links this entity to the Event which caused the Service Component to be in its Current State.

Child of: Service Component via Network Entity id number, Event Wia Event id number. Millian . S. Allah

Old State Made Lower Free State Clothy Law

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1. 1 B 1.34 5

Previous states of each Network Entity. This entity also describes the duration of time (in seconds) that the Network Entity was in a particular state. Suppose of a second

Child of: Service Component via Network Entity id number, Event via Event id number.

FR PVC Daily QOS and the case of the construction

FR PVC Daily Quality of Service. This entity describes the quality of service provided, for each Frame Relay PVC Network Entity, with respect to availability time, outage time, etc. on a daily basis. The QOS statistics are derived from the data contained in the Old La Series of the control of the State entity.

Child of Old State via Network Entity id number.

FR PVC Monthly QOS 12 2 12 2 and an incustion.

FR PVC Monthly Quality of Service. This entity describes the quality of service provided, for each Frame Relay PVC Network Entity, with respect to availability time, outage time, etc. on a a. The QOS statistics are derived from the data contained in the Old State entity. 25 32 CONTROL OF Child of Old State via Network Entity id number.

ATM PVC Daily QOS AN DESCRIPT of all six square

ATM PVC Daily Quality of Service. This entity describes the and the state of the transfer Mode provided, for each Asynchronous Transfer Mode PVC Network Entity, with respect to availability time, outage time, etc. on a daily casis. The QOS statistics are derived from the data contained in the Old State entity. The contained in the Old State entity.

Child of: Old State via Network Entity id number.

ATM PVC Monthly QOS

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ATM PVC Monthly Quality of Service. This entity describes the quality of service provided, for each Asynchronous Transfer Mode PVC: Network Entity, with respect to availability time, outage time, etc. on a monthly basis. The QOS statistics are derived from the data contained in the Old State entity. Child of: Old State via Network Entity id number.

TDM, Daily QOS VICES STEEL TO SERVICE STEEL STEE

TDM Daily Quality of Service. This entity describes the quality of service provided, for each Time Division Multiplexing Circuit Network Entity, with respect to availability time, outage time, etc. on a daily basis. The QOS statistics are derived from the data contained in the Old State entity. Child of: Old State via Network Entity id number.

TDM Monthly QOS

TDM Monthly Quality of Service. This entity describes the quality of service provided, for each Time Division Multiplexing Circuit Network Entity, with respect to availability time, outage time, etc. on a monthly basis. The QOS statistics are derived from the data contained in the Old State entity. The state of the state

20 Child of: Old State via Network Entity id number.

System Entities, 47 . so 100 (Essimply of Price To write up to

Line the Service Info-; gridentians of heaven after grident

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This entity is used as an attach point for addition description information relating to the Network Entities.

> Child of: Service Component via Network Entity id number, Info Type via Info Type id number, A last 1300 to 12

ATA AND Dutin Quality of Secretary page Type Tables of Secretary

This entity is used to specify the type of service information that can be associated with each Network Entity.

30 Parent to: Service Info via Info Type id number.

Stat Collector Info and State DO and an Large to a second and

This entity contains information regarding each set of statistics that is collected. COS Manufaction Cost

Event Collector Info

35 This entity contains information regarding each event collection session.

46020 Event Translation

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This entity maps 46020 events to Resolve events.

46020 Stat Translation

This entity maps 46020 statistics to Resolve statistics and indicates which statistics should be gathered for the Resolve Databases.

TIT. 1 2VE

1.5 mg grid 46020 CallAtt Translation of the glift in the confidence of the

This entity maps 46020 objects to Resolve Network Entities. This includes the ability to map more than one Network Management Joseph Sayang rain was as in a System's objects: the marketing a factor of the control of the co

to the contract Table Version Infogunação en 291 har double de construction de

This entity is used to track the version of each physical table in the 10 Resolve Databases. This table ensures that incorrect versions of a leading to the second and the data are not restored. They is the second of the medical country of

The control of the Archive Info full peak of the property and easiers on each the error fact

This entity tracks all Resolve archives, both full database backups of the SMIB and SIB, and daily table backups within the HIB.

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This entity keeps track of all the dbspaces available and in use in the Resolve Databases. This entity is used to maintain the large inflow and outflow of data to the HIB.

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The Physical Database Design is the physical, or actual, representation of the Object Model and Logical Database Design. In most instances, the physical design maps quite His and a closely to the logical design, but some deviations may be to achieve greater response performance, or to take advantage of additional features of the RDBMS employed, or to

to be a relative manager to be and rite we college a field of the first these well

The SMIB 2 is an operational data store. It contains both 'soft data' data (customer, contract, SLA) that can be derived from other Service Provider systems, and data that is in a constant state of flux - Service and Service Component data.

The SMIB 2 is the definitive source from which to derive inventory and status reports on 30 the Networks, the impact on Service Provider Customers, and the appropriate individuals The property of the contact with respect to Network events. I said of the creat has but a rule that

Due to the fact that a sizable portion of the SMIB's data is changed daily, the SMIB is enabled as a transaction logging database. That is, any changes made to the SMIB are not only stored in the database, but also recorded in transaction logs that can be replayed in the event that disaster recovery is necessitated, thus the SMIB can be recovered up to its

most recent update

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Note that the data contained in the Events, Current State, and Old State entities is only a single days worth. This data is migrated, nightly, to the HIB. The SMIB is shown in Figure 4.

The HIB 3, shown in Figure 5, is a very large store of data. It contains Network Events, the corresponding Network Entity states, and the Network Performance Statistics for all the Network Entities that are currently being tracked (as indicated in the SMIB). By volume of data, the HIB is approximately 40 to 50 times larger.

In the simplest sense, the HIB is a data warehouse. It contains very large volumes of data, covering the same Network Entities over a period of time (60 days, in the case of Resolve 10 1.0), and the data is never updated by end users, or by connecting systems.

The HIB is NOT a data-warehouse from the view that it does not contain data brought together from multiple heterogeneous data sources, but this is a discussion that is of little relevance to this document. Suffice to say, that the HIB contains a very large volume of data that is quite static in nature.

- The daily Events, Current States, and Old States are migrated to the HIB from the SMIB nightly, and the Network Performance Statistics are loaded; from flat files (created by the Network Interface Stats Collectors see Resolve Release 1.0 "Architect" Network Interface for 46020 Detailed Functional Specification: reference [8]) into the HIB nightly.
- The data in the HIB is held on-line (within the active database) for a period of 60 days, and is then purged. It is however, saved on tape; and may be recovered for additional analysis with the assistance of the Resolve Administrator.

Unlike the SMIB 2, the HIB 3 does not employ transaction logging, meaning that the HIB

cannot be recovered to the most recent point in time. Recovery to the most recent point in

time, however, is not necessary as the HIB does not permit user updates against it. Since

the only updates are performed by nightly processes, the new data added to the HIB daily

is archived to tape by one of these processes. Thus, any disaster recovery may be

performed by the Resolve Administrator using the daily data that has been archived to

39.5. The SIB 4 contains the end product of all the data collection and processing efforts. It is here that the end users of Resolve 1.0 may most easily extract meaningful information.

All the information in the SIB is summarized and processed data extracted from the HIB.

The processes to create SIB information may be customized to suit a particular Service

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The information in the SIB, like that of the HIB, is static in nature as it is not updated or modified by users or processes. Because of its condensed nature (a single days worth of statistics for one service component equates to 96 records in the HIB, but only one record in the SIB), the SIB can present information covering a broader time period (180 days).

The Quality of Service entities are derived from Old State data in the HIB, and the Network Performance Statistics are summarizations of Network Performance Statistics in the HIB.

Like the HIB 3, the SIB 4 does not employ transaction logging. It does however, have regular backups of the entire SIB made. In the event of a disaster, the Resolve

Administrator could restore the SIB back to its current state by restoring the most recent backup.

The SIB 4, shown in Figure 6, contains the end product of all the data collection and processing efforts. It is here that the end users of may most easily extract meaningful information. All the information in the SIB is summarized and processed data extracted from the HIB. The processes to create SIB information may be customized to suit a particular Service Provider.

The information in the SIB; like that of the HIB, is static in nature as it is not updated or modified by users or processes. Because of its condensed nature (a single days worth of statistics for one service component equates to 96 records in the HIB, but only one record in the SIB), the SIB can present information covering a broader time period (180 days). The Quality of Service entities are derived from Old State data in the HIB, and the Network Performance Statistics are summarizations of Network Performance Statistics in the HIB.

Like the HIB, the SIB does not employ transaction logging. It does however, have regular 25 backups of the entire SIB made. In the event of a disaster, the Resolve Administrator could restore the SIB back to its current state by restoring the most recent backup.

 $(a,b,c) \in \mathbb{R}^{n}$. The second $(a,b) \in \mathbb{R}^{n}$ and $(b) \in \mathbb{R}^{n}$ and $(a,c) \in \mathbb{R}^{n}$ and $(a,c) \in \mathbb{R}^{n}$

The operation of the system will now be described. When the database server is started (or restarted), the instance of the Director on the server starts a ckdbmon process for each instance of Informix Online that exists on that server. That is, if two Informix Online servers are running on the same workstation (this is a distinct possibility), two instances of ckdbmon will be started. Each instance of ckdbmon will start its own instance of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started of the ckdbmon log tool 8 (ckdblog) in the started log the started lo

Additionally, the cron table is set so that regularly scheduled database jobs are initiated.

These jobs are run nightly and accomplish the task of migrating data from the SMIB 2 to the HIB 3, and summarizing the data in the HIB 3 and deriving quality of service (QoS) information, and statistical summaries, and placing this information in the SIB 4. Other

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nightly jobs, archive the data collected daily for the HIB 3 and store it for future reference in an AIB (Archive Information Base). Figure 2-3 describes the nightly flow of data and the high-level processes involved in this flow of data. Lastly, utilities to remove old data from the HIB and SIB, and to restore old, archived data from the AIB to the HIB 3 and SIB 4 are provided.

With this feature network statistical data that can reach volumes of up to 600 million rows in a single table at one time. Obviously, a table of such proportions would require some indexing or searching for specific data within it would be a tiresome and time consuming task. Conversely, attempting to load an additional 1 million records into this table, having an index, could take days, as the amount of time required to load data into an indexed table grows exponentially with respect to the volume of data already in the table. In order to avoid this costly operation, a new work table is created, with the same structure as the table containing all the existing data; but without any indexes. Data is loaded at a much faster rate (the amount of time required to load data into a non-indexed table is a linear function, with the constant being very close to 1 that is the miliber of records by a set factor of time). Figure 4 illustrates the use of table fragmentation as it is employed by the System Database Management Framework.

Data is loaded, from an ASCII delimited flat file into the temporary working table, that

has been created in its own dbspace (1). One days worth of data is loaded into each
dbspace. Once this work table has been loaded, advantage can be taken of its smaller size,
relative to the larger HIB data table (1 million rows vs. 600 million rows for stats), and
the fact that it contains a single full days worth of data (a day is the smallest unit that the
SIB data is summarized on), to perform any summarizations or quality of service (QoS)
derivations to be loaded into the SIB on this work table.

In addition, the original ASCII delimited file is archived in the AIB (2), and this fact recorded in the SMIB, so that this data can be re-examined even after it has been aged and purged from the HIB and SIB. Again, this ASCII file contains one full days worth of data. The aged data that currently exists in the HIB dan be easily removed by simply detaching the dbspace that contains that particular days worth of data from the main table and then deleting that single portion (5). This reduces the time that would be required if the data were to be deleted directly from the main table (the dbspace that has just been cleared of aged data can then be reused as the work dbspace). Finally, the work table is attached to the main table and the indexes on the main table are

Finally, the work table is attached to the main table and the indexes on the main table are rebuilt - but only the portions of the index relating to the newly attached data.

Table fragmentation, that is the actual data in a fragmented table can be separated, using coops one of three methods nab be a fill all a sub one grister where one is a fill all a sub one grister where one is a fill all a sub one grister where one is a fill all a sub one grister where one is a fill all a sub one grister where the fill all a s

a for the alternativative summands, and placing his information in the 100 4. Other

- 1. Expression Based Fragmentation all data is placed in a dispace based on a expression involving a column or columns within the table (e.g. a table containing phone numbers may be fragmented using expressions based on ranges of area codes).
 - Hash Fragmentation a unique, or key column in the fragmented table is put through a hashing formula to determine which dbspace that particular record should reside in.
 - 3. Round Robin all data that is inserted into the fragmented table is distributed evenly across all dbspaces in the fragmented table.
- An interesting characteristic about the Round Robin method is that any data that is in a dbspace that is attached to a fragmented table (vs. being inserted directly into the fragmented table), is not redistributed to other dbspaces within the fragmented table. This means that as long as the System utilities do not insert data directly into the main, fragmented tables in the HIB, but instead, create work tables and load them and attach
- them to the main fragmented tables, it is possible to know exactly which dbspace contains a particular days worth of data.

While the same statement is true when using the other two fragmentation methods, both of those require the Informix engine to check each row of data in both the fragmented main table and the work table prior to allowing the attach to take place. Conversely, no

- row checking is done when performing an attach operation using the Round Robin method. The difference between Round Robin and Expression Based fragmentation, in the time required to perform an attach operation, is huge. Therefore the Data Management Framework uses Round Robin fragmentation, and the rule that no data may be directly inserted into a main table in the HIB is strictly enforced.
- Each of the main data tables in the HIB (events, old states, FR Network Performance, and ATM Network Performance) are fragmented using Round Robin fragmentation, and each has a finite number of dbspaces dedicated to it. Typically, there are 60 dbspaces per table, for 60 days worth of data, and an additional 15 dbspaces for the retrieval of historical data that has already been removed from the HIB and now resides only in the AIB.
- Since the row size and the number of records per day varies between the tables in the
 HIB; the dbspace sizes are different for each table. This necessitates that the each dbspace is dedicated to one and only one table.
 - Because the system HIB only stores a finite number of days worth of data; the dbspaces for each table can be recycled, with old aged data being removed and new data being
 - added using the same dbspace. Figures 7 29 demonstrate how this is performed from a dbspace usage level. but the distance of the Control of t

The table salled dbspace usage is a table in the SMIB (the actual name is txd_dbspaceusage). This table is used by the utilities loadhib event, loadhib ostate, loadhib_frnp, and loadhib_atmnp, and it allows these utilities to identify the dbspace that contains data that is a particular age (in the example, 60 days old), to remove that data by detaching the dbspace, and then load the new data into that dbspace, and update the dbspace usage table (Figure 3-4);

> The SMIB is the operational data store of the system Databases. This means that the data contained in it is timely and can change frequently.

In order to keep track of current network path (or network entity) status, the operational 10 and administrative states of each path, as well as the events that caused a path to be in that state, are recorded in the SMIB. Event data is stored in the tev event table, while the current state of each path is stored in the tcs_currstate table. Querying the current state table will allow the user to build up-to-the-minute inventory reports of available paths, and operational reports of path status'.

Since this state information is also required to derive long term availability information (used to measure compliance to service level agreements), the non-current, or 'old' state data is also saved and maintained (this is stored in the tos oldstate table). Within the SMIB, each time the state of a path is updated (in the current state table) a database trigger (add_state_rec) creates a new record in the old state table indicating the old states of the path, the time that it originally entered that state, and the amount of time (in seconds) it remained in that state. The seconds is the seconds of the seconds. 1.1.1 All of this data (the events and states) is migrated nightly to the HIB as it quickly

changes from being critical, timely information, to data that can be used to track SLA compliance. Be milita visoles el S. H. ed. al Llusur (E. 19 og elle Cari

Since events are constantly occurring, and it is necessary to keep the events, current state, and old state tables synchronized; a suspend collection signal is sent to the events collectors, via the Network Interface Director's interface process called RCI. This suspend collection signal will cause the events collectors to stop inserting new events into the SMIB and instead, store those events in buffers until the previous days worth of 230 events and old state records can be removed from the SMIB. At that point a resume collection signal is sent, via RCI to the Director and, to the events collectors, and normal processing resumes, with any buffered events being processed first. Figure 11 is a simple timeline demonstrating the various combinations of events and states (with respect to start and completion times) that may exist in the events table in the 35 SMIB. Events 0 and 1 occurred prior to the day that is being processed (October 10, 1996), but the state that events 0 and 1 placed paths 0 and 1 in respectively, continued

into the processed day. Event 2 placed path 2 in a state that both started and completed (at

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Event 2') within the processing day. Event 3 occurred in the processing day, but the state of path 3, caused by event 3, continued into the next (the current) day, as did the state that is a event 0 placed path 0 in. The state of the second of

Since the SIB reports on summarization's in strict one day intervals, and since the HIB 5 contains all data that is one day old or older, from Figure 8, it is apparent that a method to include those events that are still current (the state has not changed yet), but that occurred prior to the current day must be devised.

The strategy, as implemented in the System Database script unload_smib, is to add a column onto the end of each old state record in the old state tables in both the SMIB and HIB. This column, called the partial column, contains a 0 if the record has been completed prior to the end of the previous processing day (midnight) - the states caused by events 1 and 2, in Figure 8, fall into this category if processing for October 10, 1996 is being performed (as expected) in the early morning of October 11, 1996.

Any events in which the state is still current, as is the case with states 0-0' and 3-3', in 4 15 Figure 11 (as derived by joining the events table with the current state table) will have that current state placed in the old state table, but be indicated as partial by placing a value of 1 in the partial column of the old state table. The current state records (relating to events 0 and 3) will remain in the SMIB, as will the matching event records (events 0 and 3), but a record of the event that caused the current state, and the duration, up until midnight, is now recorded and moved to the HIB. Since states that do not complete prior to midnight processing are placed in the HIB as partial records, these records must be replaced with either a new partial records or completed records the next processing period. Thus, full data, up until 12:00am of the current day is available in the HIB, and data integrity is insured as the partial records are updated or replaced. This is shown in the 25 tables below. complete the second for relief to each 2 EO box amount 8th or to each off the

Eve	nts	Current State	Old State	
Pathld Event	tld time EvType	Current State Pathld State time Eventld	Pathld Eventld time Sta	te Duration Partial
19 10 30 miles	10 ₆₀	10000000000000000000000000000000000000	MR PLADES TO 167	This we
3 pre2 3	t3 A	Threshold of AHH and all	yunder broke in the studies. 3 pre3 type3 B	t3-tpre3 0
	25 12 YAS 1 23 DE	and records firm, the more	pre2 tpre2 B	t2-tpre2 0
1 1'	tl' B	3 A 3 3 3 3 3 7 2 1 1 1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2	1 1 tl A	tl'-tl 0
2 ' 2'-			2 2 2 12 A	12'-12 0
Service of the first service	Hita. vit. Littleff	Patient France in and I	Company of the State of the	1374 874

Contents of the Events, Current State, and Old State tables in the SMIB, at 11:59pm, October 10, 1996 The Events table will contain all events that occurred either during the hours of the processing day - Oct. 10 (events 2, 3, 1', 2') or those which were current events as of 30 12:00am of the processing day (events 0, 1). Note that the old state table will only contain records of previous states that were in effect at some time during the processing day. This

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enced as a final concept by any

is why there are old state records relating to events pre2 and pre3 - the states pre2-2 and pre3-3 were in effect as of 12:00am, Oct. 10.

The following table illustrates the changes that occur in the old state table in the SMIB . during nightly processing, as performed by unload smib.sh. The current states of the paths are written to the old state table as partial records with duration's calculated to midnight of the processing day.

PathId EventId time State Duration Partial 3		-	- " .		
2 pre2 tpre2 B t2-tpre2 0 0 0 10 A midnight Oct.10 - t0 1 1 1 t1 A t1'-t1 0 3 3 43 A midnight Oct.10 - t3		Pathld Eventld time	State Duration	Partial	-
2 pre2 tpre2 B t2-tpre2 0 0 0 10 A midnight Oct.10 - t0 1 1 1 t1 A t1'-t1 0 3 3 43 A midnight Oct.10 - t3		3 pre3 tpre3	3 B t3-tpre3	0	taria (fil
1 1 A tl'-tl 0 3 3 43 A midnight Oct.10 - t3 1 1		2 pre2 tpre2	B t2-tpre2	0	
1 1 A tl'-tl 0 3 3 43 A midnight Oct.10 - t3 1 1		0 1 to	A midnight C	oct.10 - t0 1	i i
3 43 A midnight Oct.10 - 13 1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2		$\mathbf{L}_{\mathbf{L}}}}}}}}}}$	A tl'-tl	j 0	
2 12 A 12 12 13 14 10 10 10 10 10 10 10 10 10 10 10 10 10		3 43	A midnight C	et.10 - t3 111	
		. 2	.A. t2 -t2		
2 2 12 A 12 12 1 1 1 1 1 1 B midnight Oct. 10 - 11 1		' 1 ' 1'' ' ' ' ' ' ' ' ' ' ' ' ' ' ' '	B midnight O	ct.10 - t1' 1 1	•
2 12'0 B imidnight Oct.104 t2' [1]	1. 1. 1. 1. g 5.	` 2 _{~~~} 2'	, B midnight O	ct.10 - t2' [1 :	1 mg - 1

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Partial Records placed in the SMIB Old State table during unload smib.sh processing All old state and event records which have a timestamp of a day prior to the current day -10 Oct. 11 (states 0-0', 1-1', 2-2', and 3-3', and events 0, 1, 2, 3, 1', and 2') will be copied into ASCII delimited files for loading into the HIB, and all non-current event (events 0, 1, 2, and 3) and all old state records (states 0-midnight Oct 10, 1-1', 2-2', 3-midnight Oct. 10) will be deleted from the SMIB. The following tables illustrate the state of the HIB, prior to nightly processing of Oct. 10th data; and the state of the SMIB and HIB a first of the processing of Oct. 10th data, and the lates of the first of the

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which are the existence of Events are sained as EUH count becen Old State tip 20 por pright but if
0 0 t0 A 0 0 t0 A midnight Oct.9 - t0 1
1 1 t1 meA = 9ft 10 = 100 1 t1/2 Weindnight Oct.9 - t1/2 t1/2 pre2 tpre2 B 2 pre2 tpre2 B midnight Oct.9 - tpre2 1
3 si pre3 tpre3 B = 1 pre3 tpre3 B midnight Oct.9 - tpre3 1
```

The state of the HIB Events and Old State tables prior to unload_smib.sh processing for Oct. 10th data Prior to loading the event and old state records into the HIB, any event records which are related to partial old state records, and the partial old state records themselves (in the event and old state tables in the HIB), are deleted. These will be replaced by either new partial records, or completed records from the most recent day prior to the current day.

```
Current State
                                                                                                                                                                             Events
                                                                                                         PathId EventId time EvType
                                                                                                                                                                                                                                                                                                                                                                                        Pathld State time EventId
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Pathld EventId time State Duration Partial.
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                         tin as author sections of the section and the fill the file.
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SMIB data in the Events, Current State, and Old State tables immediately after unload, smib.sh processing of Oct. 10th data and instructional and series as the series and the state of the first of the series of the series and the series of the seri

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Path Id	EventId	time	ÉvType	Pathl	d Eventid	time Stat	e Duration		Partial
				. , 3 ,	pre3	tpre3 B	t3-tpre3 t2-tpre2	m. 165 1	, 0
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i i	·i·	tl '	Α	. 1	"" 1 " " '	tl A	tl'-tl		0
['] 3	3	t3	Α .	3	· 3 ·	13 A	midnight t2'-t2	Oct.10 - t3	,; ,1
2	2	t2	Α	2	2	12 A	t2'-t2		. 0
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2	2'	t2'	В	2	2'	t2' B	midnight (Oct.10 - t2'	1
<u>.</u>	1000		in and		آ مها ۱۵ با آ ^ا	Particle 20		1 14	

HIB data in the Events and Old State tables immediately after unload_smib.sh and loadhib_event.sh and loadhib_ostate.sh processing of Oct. 10th data

There is one additional occurrence that must be processed in the Events and Old State tables in the SMIB. It is when there are new events, that have occurred after midnight of the processing day, but prior to the nightly processing being performed. The old state and event records of this type must be kept after the nightly processing, or the next day's processing will be inaccurate. To accommodate this occurrence, a partial type of 2 is placed on these records. They are not unloaded, nor are they deleted from the SMIB. The last step of the nightly unload_smib process sets these partial types back to 0, after the other event and old state records have been unloaded and deleted from the SMIB. There exists, within the System Database Management Framework, the ability to restore aged data that has previously been removed, or purged, from the HIB. The principle behind this function is similar to the principle applied by the HIB storage management tracking dbspaces availability.

Each table type in the HIB (currently Events, Old States, FR Network Performance, and ATM Network Performance) has a limited number (typically 15) spare dbspaces reserved for aged data. This is data that is older that what is considered active data in the HIB (older than 60 days in this example).

The following table illustrates how the data in the dbspace usage table is applied to locate a dbspace of type event that is not currently used and is available (indicated by a NULL value in the last usage date column, and the 1 in the available column). refreement due <u>Landry (FA P. II.</u> 93

	- DBSpace Osage Table
.45 A Ch T	 DBSpaceName DBSpace Number Object Type Last Usage Date Available

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	`∙d661 05321 5¶0	266	CCE event	ល់នៅដែលសមាន នគ្គា 🗀 🖼 🤊
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The actual aged data ASCII delimited files are tracked by another storage management table in the SMIB call the archive information table. This table gets updated every time an archive of HIB data occurs. The type of data (events, old state, etc), the volume label of the tape or file that the ASCII file is stored on, the date of the data, and the version of the table structure (for future use) is recorded.

When a user of the System System wishes to analyze aged data, a request for the data is made to the System Administrator. The System Administrator can then use the restore script to first, select the particular data that was requested; then restore it to the HIB. When that data is restored, the dbspace usage table is updated to indicate that this data is now in the HIB and the dbspace used is not available for other restores until this data has been removed again from the HIB.

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	262	event()	1996-08-10	0				63.00	
db61 db62	266 · 270	event ·						ad	

updated dbspace usage table with restored aged data

Newly aged data (data that has just become older than the active data) is automatically purged with each nightly run of the loadhib scripts. However, aged data that has been restored by the restore is not purged. This is due to the fact that the restored data was restored for further analysis and should therefore be kept in the HIB until it is no longer required. The removal of this data requires proactive steps to be taken by the System Administrator. Using the purge hib and purge sib scripts the System Administrator can list all data that is older than active data in each of the HIB and SIB respectively. 20 purge_hib will use the dbspace usage table to determine the number of days old the aged HIB data is relative to the current day. Once purge_hib is executed, any data as old or older than the number of days old selected will be purged and the dbspace usage table will again be set in indicate that the dbspaces that were used for the purged data are now available, and the last usage daté is again set to NULL.

purge_sib will scan the date values in the SIB to build of list of days of aged data. This is a slower process, but due to the lessor volume of data in the SIB (relative to the HIB)

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performance should not be an issue. As with purge_hib, purge_sib will delete any data that is as old or older than the days old value passed to it.

Informix Online provides support for Referential Integrity in the form of Referential Constraints (foreign keys). The RI constraints ensure that a child record cannot be added if the relating value does not exist in the parent table, and conversely, that a parent record cannot be deleted if a child record relating to it exists. These relations deal with physical occurrences of records.

However, some entities within the System databases are related to each other on a logical level. That is, some entities (user, person, service contract, customer, etc) can be flagged as logically deleted, in which case they are no longer available for reference or manipulation via the Configuration GUI or Reporting tools, but they physically remain in the database. Since these records are not physically removed, there is no way of enforcing RI constraint rules. In response to this, what has been implemented is a set of triggers, activated upon the update of the 'deleted' indicator column in those tables, that call stored procedures that check for child records that have not been logically deleted. Table 3-1 lists each parent table, its child tables, and the trigger that is activated upon a logical delete.

Parent tal	ble	Child table	Trigger
tcu_custo	omer and the stage of	ter contract	process_cust_upd
tcr_contr	act	tse_currservice tse_currservice tco_contact	process_contr_upd
ton comm	orofile	tce curreervice	process sp. lind
tse_currs	service	tsc_servcomp	process_serv_upd
tpe perso	3 5 900.5 . 6 1, 2 on	tco contact TOP POWER TO FINE TO A DECEMBER OF THE ADDRESS	process pers upd
tro_role	n myra i i beber n	tus_user tus_user tea_entityaccess	check role child

Data Integrity Triggers of the SMIB

Due to the very large numbers of DASD devices required for a full System, there are several files that must be customized on a per installation basis. The altering of these files can have dire consequences as they relate to the System.

1. links.sh - this file creates the symbolic links for the database that are used by Informix Online for dbspace files. This file will require that the devices linked to, and the chunks linked to each device are defined. Additionally, the symbolic links to the tape

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- devices required by the System Databases (two devices one for log files, the other for archives) must be defined. A Style of the style of th
- 2. onspace.sh this file creates the dbspaces on top of the symbolic links created by links.sh. The onspace commands specify not only the dbspace name and the path of the chunk supporting the dbspace, but also the bytes offset and the size of the dbspace. For this reason (specifically the offsets), onspace sh must match the links sh file. If it does not, the installation will proceed, but the System System will not function as some dbspaces will not be brought on-line due to incorrect space allocation (incorrect offsets).
- 10 3. dbspaceusage.sql this file calls the stored procedure, init dbspaceusage, which seeds the dbspace usage table for storage management. If the system you are installing will store 60 days of active HIB data, this file does not need to be changed. However, if you plan on storing more days or less days of HIB data, the first parameter in each execute procedure statement must be updated to reflect this.
 - 15... 4. storage.cfg this file indicates where files are located, names of system tables, and the number of days of HIB and SIB data to be stored. If the number of days of HIB data stored is not 60, or the number of days of SIB data to be stored is not 180, this file must be updated to reflect this.

When the System Database is first installed, it is prepared, and expects, to accept data immediately. Conversely, if data is not submitted to the HIB processes for a period of time immediately after the system has been installed, The Data Management Framework processes will automatically perform the necessary alterations to ensure smooth operation.

Descriptors are used in the system as more fully described with reference to Figures 13 to

Figure 13 is an overview of the object models for a TIM (Telecom Information Management) architecture.

Figure 14 shows the types of descriptors that are provided in a typical system for managing service level agreements. There is a top level descriptor, and derived descriptors relating to various aspects of the system.

The top level descriptor stores meta information on entities. The base class provides a template where unique Ids, names and descriptions are stored. The derived classes define additional qualities for specific descriptors.

In a service level management system, the use of descriptors enables new service level agreement thresholds to be added to the system without modifying the service profile code. For example:

> Export Control: Public

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٠.	Cardinality Comment in the Survey of the	u jan era era era da.	o ne 16 also ii v	.
	Hierarchy:			
	Superclasses: None			
17, 3 71	Private Interface:	va admous 1 cum	प्रदेश के सम्बद्धाः स्टब्स्ट	
5	Attributes: 1990 Top on the land	চা ক্ষেত্ৰতাত বুল্পী ুজ	LANCE COLOR	> .
· · · · ·	energy of the man has type: shorter and	าลา สมเผยกรัฐอำกันส		
	The desc	riptor uniquely id	entifies the descriptor	record
••	instrincts of the elementary resembles attached to	to a specific class	the property of the property o	
	Name:char[200]	, Amas etc e	moderate bush	•
10	To the second of	he descriptor nam	e is the unique name o	of a
	· · · · · · · · · · · · · · · · · · ·	escriptor	a property of the property of	
	Description :char	[200]	Committee of	
	and the second of the second o	ne description is a	a brief summary of the	purpose of
	in gast and in place, and a significant or so the	e descriptor		
15	State Machine: No			
ti. Si.	Concurrency Se	equential		
,	Persistence A common read to the second Persistence		(D) V (V) (A)	
	In Figure 15, the classes in the top layer	object model of	Figure 14 are defined	as follows.
	Class name:	- \$1°	•	•
20	Descriptor Annual State of the Control		1777 ATA	
2 to 1	Documentation:			
.: '\	This class is used to store meta informa			
•	template where unique IDs, names and	-		
	define additional qualities for specific d			-
25	concept is to minimize the impact of ad			
	system. For example, new SLA thresho	lds can be added t	to the system without	modifying
	the Service Profile code.		•	
·. ,	. Superclasses: (qua or merver) mer , se /	roice providor red	ကား ကြီး မြော်ခဲ့သော လေးကြိုင်	
20		•	eb world a cital and	
30	Roles/Associations:	_	4.3 利用A 会下的值。	
	<none></none>		lo degravil et med -	21
			i a and colong to bell was fi	
63447	type: short	o ere zoonakui sa	ស្រាល់ បានសំណែក សំណែក	
25	The descriptorId uniquely identifies the			class.
35 ≟ ⁄	name: char[80]	light was edinted to i	Talling by Track Miles	
•	The descriptorName is the unique name	or a descriptor.	राक्षातिष्ट्रा हो ६० गरी ६० १ असे वस	`.
	description : char[200]	•		
	•			

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Figure 16 also illustrates how descriptors are used to dynamically add new capabilities to the system. As new entities or operations on entities are defined and implemented, new entity operation descriptors are defined and added. When these descriptors are added, the user management module becomes aware of these capabilities. The user management module is used to give/deny access to specific parts of the system.

Each instance of a descriptor sources its information from a specific row in a relational database table. The following table illustrates the instance data associated with the service component descriptors for use in a system for managing service level agreements in a telecommunications network. 12 31 32

10 Service Component Descriptor

	Туре	Name	neerDescription
	0	Undefined	Undefined Service Component.
State of the second	1:7.	TDM Path	A logical end to end connection implemented using
	_	•	time division multiplex (TDM) technology.
	2	FR PVC	A frame relay path. A permanent virtual end-to-end
			connection implemented with frame relay technology.
	3	ATM VCC	A virtual channel connection. A collection of
.कर है छ। हा	ot ditte.	Salah Carl 💒	connections that form an end-to-end path through a
	-		network
	4	ATM VPC	A virtual path connection (VPC). A logical
			communication channel that is available across the
******	SEE HOW.		physical ATM interface and that can carry one or more
— b: 🖫 ш	capitals .	inikot kan	Line and ingresimal channels. All and the area of state and
			min II see qArtDM Network Interface
5 11 11 2	6,	FR CTP	County wer Frame Relay Circuit Termination Point. 1997
344ji 144 <u></u>	7	ATM CTP	tebbes ed a ATM Circuit Termination Point.
			copies the electric design

If, for example, the service provider receives a requirement to support ATM UNI services, The following new descriptors are added.

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Entity → ATM UNI

Service Component → ATM UNI 15

New descriptors are added for SLA thresholds, and statistics.

New valid operations instances are created for ATM UNI. No software is required to change in the user / security management module.

New service profiles can be created using ATM UNI without any modifications to the 20 software in this critical area ಗಳುತ್ತದೆ ಕರ್ಣಿ error common with at earth forth, with with

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New services can be configured with ATM UNI service components assigned to Committee of the second of the second them.

Within the configurator, the only software modifications required are new screens to view details associated with the ATM UNI.

The service definition layer is shown in Figure 17. 5 gar la ala Mas tindi Class name:

Descriptor

Documentation:

This class is used to store meta information on entities. The base class provides a template where unique IDs, names and descriptions are stored. Derived classes are used to 10 define additional qualities for specific descriptors. The intent behind the Descriptor concept is to minimize the impact of adding new functionality on critical parts of the system. For example, new SLA thresholds can be added to the system without modifying the Service Profile code.

Superclasses: 15

<none>

Roles/Associations:

<none>

Attributes: 3 pr. 1 posto in the after that the before the at fill in a second of A

type: short - main who is a wild that he dismontal for a bury of 20

The descriptorId uniquely identifies the descriptor record attached to a specific class.

name: char[80]

The descriptorName is the unique name of a descriptor.

description : char[200]

The description is a brief summary of the purpose of the descriptor. 25

Has-A Relationships:

<none>

Operations:

<none>

30 Class name:

ServiceEntity

Documentation:

Service entities are the base components of service model, representing the customer, the contracts owned by that customer, the services contained within the contract, and the ीं प्रकार प्रकार के जिल्ला के निवास के अपने के

to the hand calme for the directional. The value can be contoured

ner mes it a confiding ContractThresh, Add Colored

right of the STATINGS I Sentence of the section of the sentence of the sentenc

service profiles desribing the services. 35

Superclasses:

Entity this is not near a for this mental and an account to this train to a some of the

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To engine from the control and and a single of

responsibleFor in association Contact_ServiceEntity collectedBy in association-ServiceEntity_UserLogEntry Attributes: TA af the establishment of the AT

whoCreated: integer

The ID of the user who created the entity.

whoLastModified: integer

The ID of the user who last modified the entity. If the deleted flag is set this attribute holds the id of the user who deleted the entity:

Has-A Relationships:

Snone and modulation of large entrantic militage modules all lact particular is more

Operations:

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Delete() The deletion of a service entity will be tracked as a modification with the result of the delete flag being set.

Class name:

SLAThresholdDescriptor

Documentation:

A template for a Threshold object that defines the characteristics and description but not the specific value of the threshold. An SLA threshold descriptor must be created for each 20 new threshold type that the system will support. Superclasses:

he descript fixement that i doubten to be described

Descriptor

Roles/Associations:

25 measures in association ContractThresh_SLAThresh mapsTo in association SLAThresh_ServProfThresh Attributes:

defaultValue: double

A default value for the threshold. The value can be customized in each instance of the 30 SLAThreshold. Service Indire

serviceCompDescType: short

Foreign key to the type of service component this threshold can apply to. units: char[40] and Lamerons as a may be a company that yet as a year has a contract.

Description of the unit of measurement. 25 phytos orfogable autility on was exrelatedClass: short

Indicates whether this is a contract related threshold, or a service profile related threshold.

	Has-A Relationships:	(4) (4) (4) (4) (4) (4) (4) (4) (4) (4)	
	<none></none>	ें से से वार संस्था है। एक स्थाप है।	
	Operations:	machine to the con-	
	<none></none>	and and ending the second of the control	•
5	Class name:	the industry	
	FunctionDescriptor Teachers to a second	on all Mississification of the second	
	Documentation:	to prove the appropriate	
	This class is used to enumerate the descri	ptions of functions or job roles that can	be
	associated with a contact person within the	ne system. A Function descriptor must b	e created
0	for each new function that the system wil	ll support.	11
	Superclasses:	The second secon	
	Descriptor	1. 1 . 41 G	
	Roles/Associations:	516.A	
	performs in association Contact_Function	nDesc (A) The Land	
.5	Attributes:	Stories (Ellins) and	21
	<none></none>	esta de la martina	
· .	Has-A Relationships:	NA HOME TO A STATE OF THE STATE	
: 1		efinseveroult (1805), in a formal	
	Operations: 1900 Passes & trees from the East and		
20	<pre><none> / fixed for return fixed and act</none></pre>		V.
	Class name:-1" เกาะเหตุ กูปักษณะ หลัก (ก.ศ.) สถ		
. *	Contact [0.01 M grant quit construit of		
	Documentation:	81-8 5778 & \$1000 & 986	
	A Contact unambiguously identifies a pe	rson who carries out a role associated w	ith a
25	specific Service Entity. The class provide	es the necessary information to contact t	hat ²
	person. * * definition from NM Forum -		Paper,
	September, 1995 (NMF/SPT95-15)		
	Superclasses: destital8 grandlos	na vilkur i ukyan kulu, uki n ciai luu Conat	
	<none></none>	The state of the s	
30	Roles/Associations:	e e na vertida di integrer	}. ?
	hasContact in association Contact_Service	SeEntity (I) grant which good as and its	
	performedBy in association Contact_Fur		
	actsAs in association Person_Contact	hardyr cyllaconrollar abiol This fill	
	Attributes:	e aktyrające ki 10000 Dk ACDT.	
35	serviceEntityId: integer	no dzi own Medniumbi.	
	Foreign key to the service entity class. R		can be
	used for.	કાર્લા હૈ . હિં7	

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serviceEntityType: short

Foreign key to service entity table.

personId: integer

Foreign key to the person class. References the person who acts as the contact.

personType: short

Foreign key to person table. This field always contains the same value indicating the entity type is "PERSON". March 19 at 1 at 1 at 1 at 1

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functionDescType: short and a second of the second of the

Foreign key to the Fucntion Descriptor class.

10 Has-A Relationships:

<none>

Operations:

<none>

Class name:

ContractThreshold 15

Documentation:

Contract Thresholds are SLA Thresholds that are associated with a Contract. The SLA is a set of technical, administrative and management parameters that the service provider can report against. They typically are based on objective measures and have a high correlation with the users' perception of the quality of service. Each parameter is typically a

20 a threshold that, when surpassed, means that the quality test in question has failed. * * definition from NM Forum - SMART Performance Reporting White Paper, September, 1995 (NMF/SPT95-15 recent at a section

The Superclasses of the admission most of a specific to the original of the

served in the median wassened and represent the property of the control of the served of the served

Burg to a Roles/Associations: Hartolita TRAMS - THAT POPULATION AND STREET usesThreshold in association ContractThreshold Contracts The Contracts The Contract Threshold Contracts Threshold In association Contract Threshold Contracts Threshold Contract Threshold Contracts Threshold Contract Threshold Cont measuredAgainst in association ContractThresh SLAThresh Attributes:

30 contractId: integer

> A foreign key to the entity ID of the associated contract. contractType: shortno a ma (Pringersociation Charact Facultion Door Foreign key to contract table. This field always contains the same value indicating the entity type is "CONTRACT".

35 thresholdType: short

Foreign key to the SLA Threshold Descriptor table

val: double

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There is the control from the doctors that the The numeric value of the threshold. Has-A Relationships: <none> Operations: <none> Class name: Company of a made see the arrival Customer on the engineering of the control of the following of Documentation: The Customer is a legally identified organization that is contracting for the supply of one or more services from one or more service providers. * * definition from NM Forum -SMART Performance Reporting White Paper, September, 1995 (NMF/SPT95-15) THE SAME CONTRACTOR STATES OF THE STATES OF Superclasses: ServiceEntity (a) A give is discountable professional according. Roles/Associations: belongsTo in association Customer_Contract ownedBy in association Service Customer and the straining to the the Attributes: name: char[80] The name of the customer or company: The name of the customer or company: idNumber: char[20] A unique number identifying the customer and assigned by operational staff (i.e. anament still believe the still and the customizable). comments: char[255] Any comments pertaining to a specific customer may be added to this field. 1984 4 34 C. A. 12 address: char[255] A street address for the customer. WW TW SEEL Has-A Relationships: <none> * Operations: A lightly boundaries on a case thing bounds by contact of success of seen assect that the could not be deleted which are consult is edition. Delete() A customer cannot be deleted while it is associated with a contract or service. All related Class name: nais one Contract

Documentation: 35

The Contract is a legal administrative and technical document describing what will be provided to the Customer, how and when it will be provided and the terms and condition

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- 31 under which it will be provided. It also describes the obligations placed upon the Customer. * * definition from NM Forum - SMART Performance Reporting White Paper, September, 1995 (NMF/SPT95-15) Superclasses: ServiceEntity Roles/Associations: maintains in association Customer_Contract isContainedBy in association Contract Service usedIn in association ContractThreshold_Contract customerId-; integer and appropriately appro Foreign key pointing to the entity ID of the customer. customerType: short Foreign key to customer table. This field always contains the same value indicating the entity type is "CUSTOMER". town the first the contract country from the effectiveDate: time rennal brita non a cilosofic The date on which the contract came into effect. number: char[20] A number used to track the contract against external systems. This number should be unique. comments : char[255], while we have many one or it get [] such lead to a page 5 and a Any comments specific to the contract. 170 500 1030 expiryDate: time Containts on tilias! The date on which the contract expires . Alberta a character of the contract expires . Alberta a character of the contract expires a character of the character of the contract expires a character of the character of Has-A Relationships: -330bs to growling <none> teman a tilbizat satishi a listiti A. Operations: rias di Polase schipe. Delete() A contract cannot be deleted while services are associated with it. All contact information associated with the contract is deleted when the contract is deleted.

s dide botoloozza ki ti skile beterali i il ti car . rate and ' The relation to a customer is set at creation time and cannot be changed subsequently. Class name:

Service

35 Documentation:

TO VIEW LONG TO , A Service is anything that the service provider determines that Customers-wish to purchase and that the service provider is willing to supply * More specifically (within the

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context of Resolve), a Service is a telecommunications product sold to a Customer by a service provider which is managed by the service provider. Services include transmission facilities and associated applications. A Service can consist of multiple Service Components. * definition from NM Forum - SMART Performance Reporting White

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Paper, September, 1995 (NMF/SPT95-15) 5

Superclasses:

ServiceEntity and an example of the control of the

Roles/Associations:

contains in association Contract Service

owns in association Service Customer 10 describes in association ServiceProfile Service containedBy in association ServiceComponent_Service Attributes:

customerId: integer

Foreign key to the customer class. References the customer who owns this service. 15 customerType: short

Foreign key to customer table. This field always contains the same value indicating the entity type is "CUSTOMER".

contractId: integer

Foreign key pointing to the entity ID of the contract. 20

contractType: short

Foreign key to contract table. This field always contains the same value indicating the entity type is "CONTRACT": i ca was male sorivers also a vessors as each month Menty asserviceProfileId: integer ए pais । एकाई उसके प्रतिप्रकारी प्राथमिक क्षा किलोबर हे निवास

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Foreign key to Service Profile class: appropriet a phogosopa, and appropried to the 25 13 2 5 1 2 5 C. serviceProfileType: short Foreign key to service profile table. This field always contains the same value indicating transitivities, we have to

the entity type is "SERVICE PROFILE".

inServiceDate: time

The date that the service came into effect. 30

serviceName: char[80]

A label for this service.

comments: char[255]

Any information added by the user which is specific to this service.

Has-A Relationships: 35

<none>

Operations:

Delete() jos 19; Contract the first of the section of the first Deletion of this class follows the rules of deletion for the entity class, and leads to deletion of all related contact information. **CurrentService** 程序 TOOK 2010年 地位主义 2010年 Documentation: This class is used to track current services. Current services become historical services everytime a modification is made to their associations with a customer, contract or service profile record. and the themselves there is a first of the second Superclasses: 10 Service SOURCE MAIN SOURCE STORY Roles/Associations: A the second of the seco <none> Attributes: والمراجع المراجع والمحاصرة 15 $_{\rm M}$. <none > . We have a substitute that the state of the st Has-A Relationships: Sand Tombers Snone - health him seven in the him of the state and the same in Operations: "A COSTA TOP A COSTA COSTA <none> TELEFF ENGINE OF 20 Class name: marked district of the second of the second HistoricalService Pera ter Televisionia Documentation: etc. 364 3.00 2 284 13 Color of Colden transport to Empression This class is used to track services that are no longer in use. This information is necessary for historical reporting. Everytime the associated customer, contract or service profile for a current service is changed, a historical service is created and a read angle of 25 35 Superclasses: out in surful Red to diense grusse, an e **Service** and experience against a bish shift ender a heart sonces project or heart Roles/Associations: CONTROL OF PERMICE SECURICES. <none> inde the charge 30 Attributes: thesite that each echine your test suit in T expiryDate: time forther to telde on Date the service was modified or went out of use. Lability and in the control Has-A Relationships: factions on a smooth 35 Operations: CMC-12 SM No Best L <none> Class name: SHOW OF STREET

the grid on gringing the in His Hi

Person

*Documentation: in the contract the first of the contract of t

This class contains pertinent information on a specific individual. เรื่องและ สารที่ พาสาร สูตรั้งที่ พายาน พระแก้ เป็นพาสมเสนาก รั้ง Superclasses: ร ค่า <u>เ</u>อาราช หลัง เราะ เกิด เรื่อง

AdminEntity

Roles/Associations:

hasProperties in association Person_Contact hasProperties in association Person User Attributes: with the National Action of the Attributes

10 name: char[20]

Full name of the person.

position: char[40] and a true a large feet to appear a manager and property and appears.

Short description of position held within the given organization. the state of the month of the control of the attention of

organization : char[80]

Name of the organization with which this person is associated. in the form of the second

telephoneNumber : char[20]

Telephone number associated with the person.

faxNumber: char[20]

Fax number associated with the person.

emailAddress: char[40] 20

Electronic mail address for the person.

mailingAddress : char[80]

Full mailing address for the person. comments: char[255] as as a character of the political engine section such as a section of

25 Additional comments specific to the person. ราวังค้า แบบ การโบาย ราการสุดสมัย**ต่อสถาการ**สุด

Has-A Relationships: The **knones** is a coccata on the although the related **of** beathful to a content of

Operations: Polices, really have block to 3 contained as electronic actions of the

<none>

The described system provides an efficient method of managing service level 30 management agreements in a packet switched network that is capable of handling vast तीत be एक १०३ वर्ग एक दूस केर बार quantities of data in a flexible manner.

वेत कर पर १५ ए वर्ष कुछ के राष्ट्रकार देखा कर जो अन्य जान जन्म कर्तन स्वकृति स्वतंत्र है कहा पारी सालपार विश्व

ा । है र द्यापीसप्रवृक्ति एवळ्ळात्रामुम् प्राप्त दीसंद १ एको स्तै हिस्स्य है । हा इस ह

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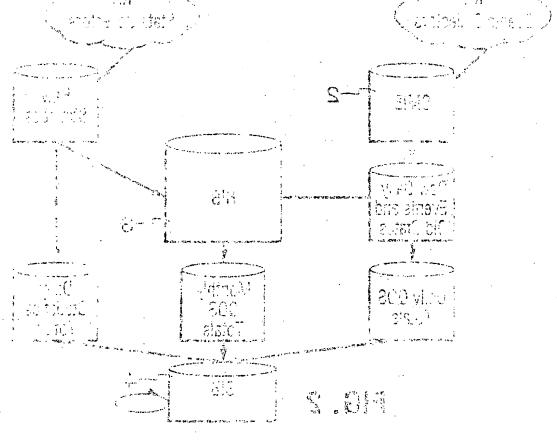
Claims:

- 1. A method managing a telecommunications network comprising the steps of:
- a) maintaining a database means containing data relating to service level agreements with customers using an object model,
 - b) receiving from the network data relating to the performance of the network,
- c) continually comparing the data received from the network with data stored in said database, and
- d) generating a report based on said data showing the performance levels for individual customers in meeting commitments stored in said database containing data relating to said service level agreements.
- 2. A method as claimed in claim 1, wherein said event is generated when the discrepancy between performance levels and commitments exceed a predetermined threshold value.
- 3. A method as claimed in claim 1 or 3, wherein a plurality of working table fragments forming part of a fragmented table are created in memory; data are loaded in successive predetermined time periods into successive table fragments in a predetermined sequence, and the data are processed separately when loaded into the table fragments.
 - 4. A method as claimed in claim 4, wherein the data loaded using a round robin technique.
- 5. A method as claimed in any one of claims 1 to 4, wherein descriptors implemented as an object oriented class are used to store meta information on other classes in the system.
 - 6. A method as claimed in any one of claims 1 to 4, wherein a base descriptor class provides a template where unique identifiers, names and descriptions are stored.
- 7. A method as claimed in claim6, wherein derived classes are used to define additional qualities for specific descriptors.
 - 8. A method as claimed in claim 7, wherein derived classes are implemented for service entities, functions, statistics, Service Level Agreement thresholds, operations, service components, etc...
- 30 9. A telecommunications network service level manager comprising:

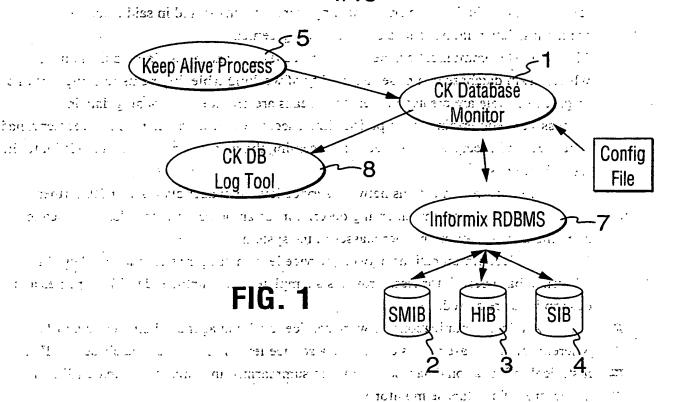
 a) database means containing data relating to service level agreements with customers using an object model;
 - b) means for receiving from the network data relating to the performance of the network;
- c) means for continually comparing the data received from the network with data stored in said database, and
 - d) means for generating a report based on said data showing the performance

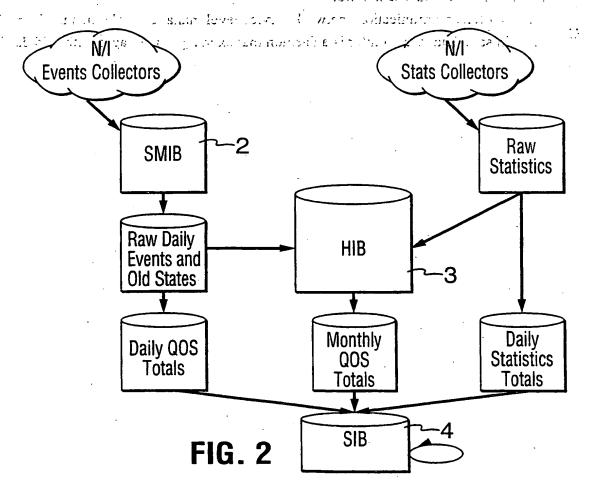
levels for individual customers in meeting commitments stored in said database containing data relating to said service level agreements.

- 10. "A telecommunications network service level manager as claimed in claim 9, wherein said database comprises a plurality of working table fragments forming part of a fragmented table are created in memory, means are provided for loading data in successive predetermined time periods into successive table fragments in a predetermined sequence, and means are provided for processing the data separately when loaded into the table fragments.
- 11. A telecommunications network service level manager claims 9 or 10, further comprising means for implementing descriptors as an object oriented class are used to store meta information on other classes in the system.
 - 12. A telecommunications network service level manager as claimed in claim 11, wherein a base-descriptor class provides a template where unique identifiers, names and descriptions are stored.
- 13. A telecommunications network service level manager as claimed in claim 11, wherein said database means comprises a service level management database (SMIB), a historical information database (HIB), and summarized information database (SIB) under the control of a database monitor.
- 14. A telecommunications network service level manager as claimed in claim 13, wherein said database monitor is a daemon that exchanges messages with said databases.



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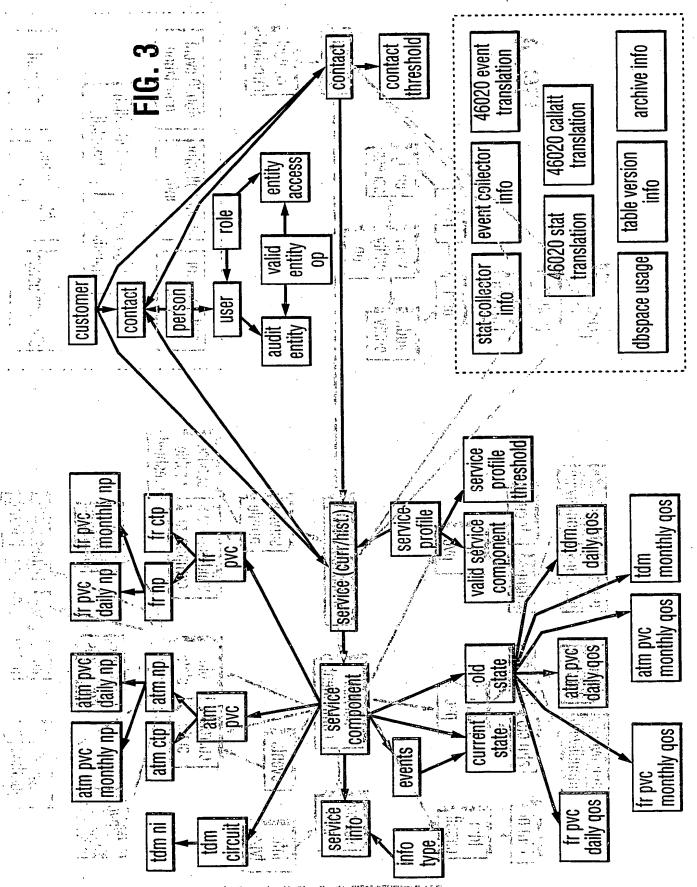


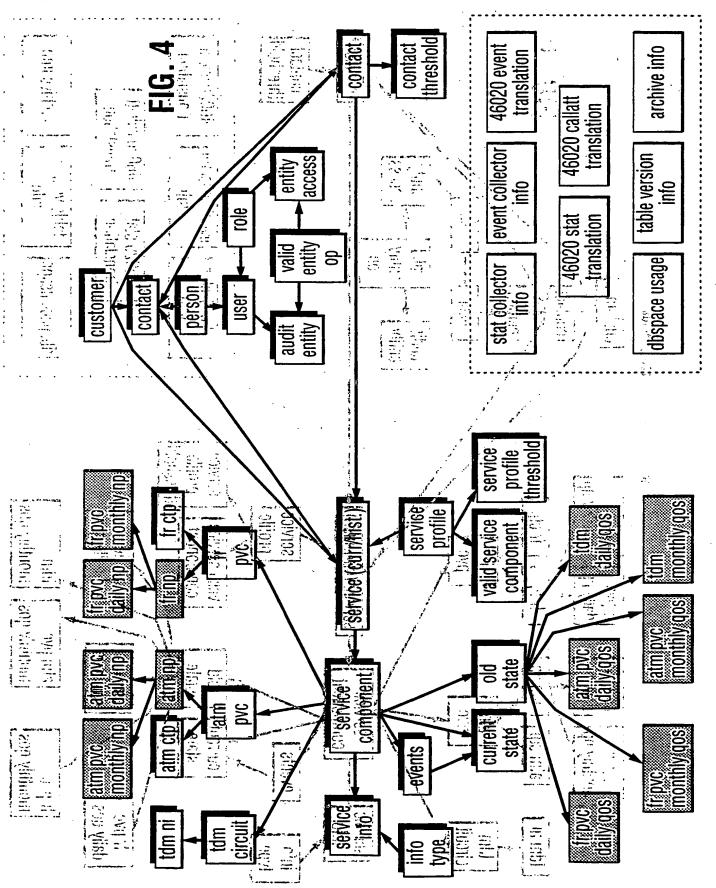


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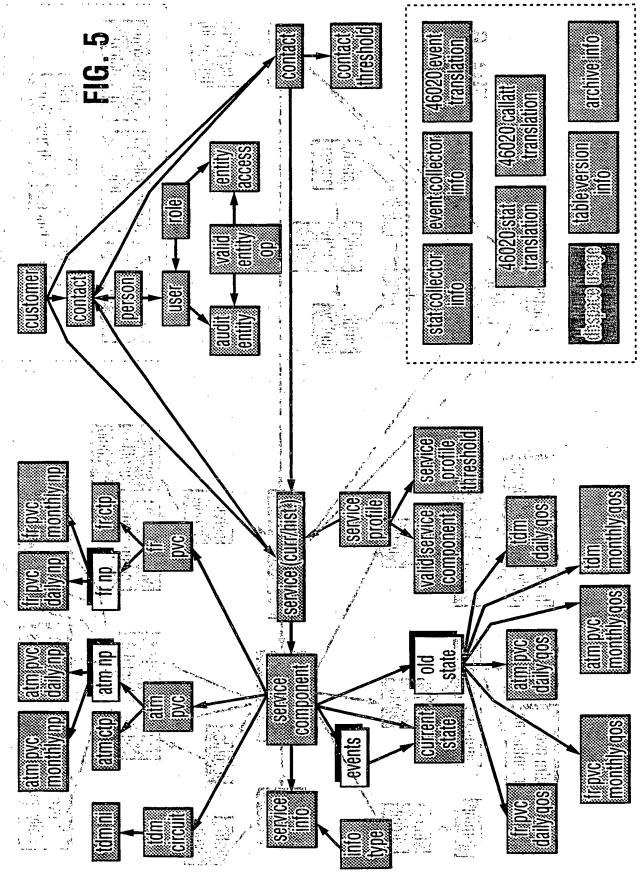
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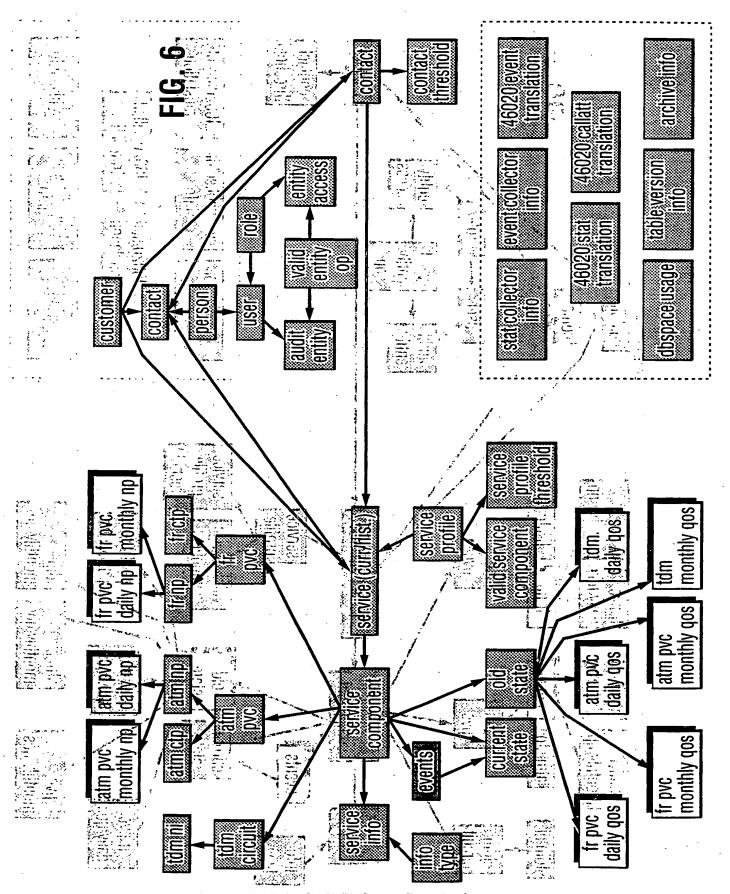


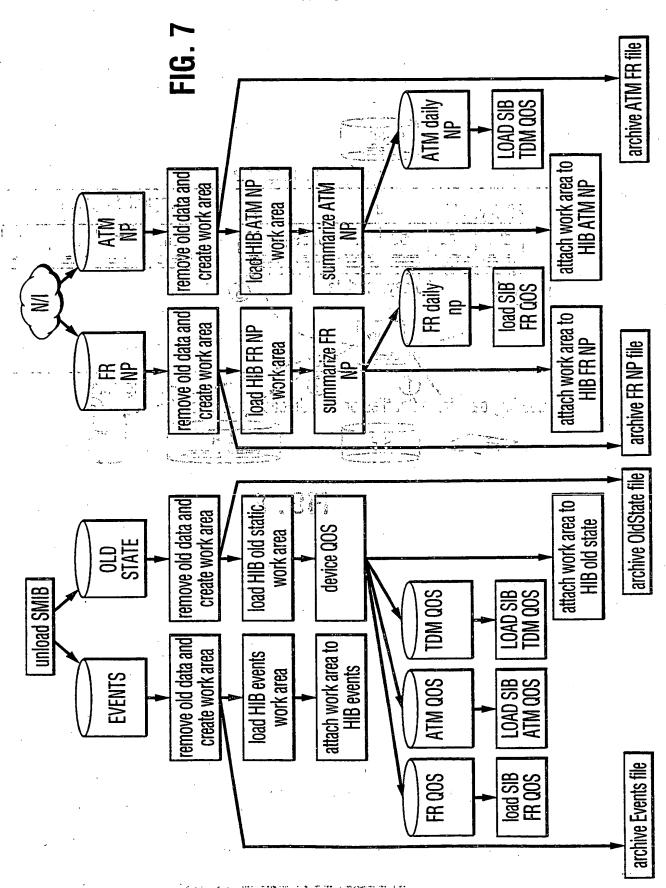


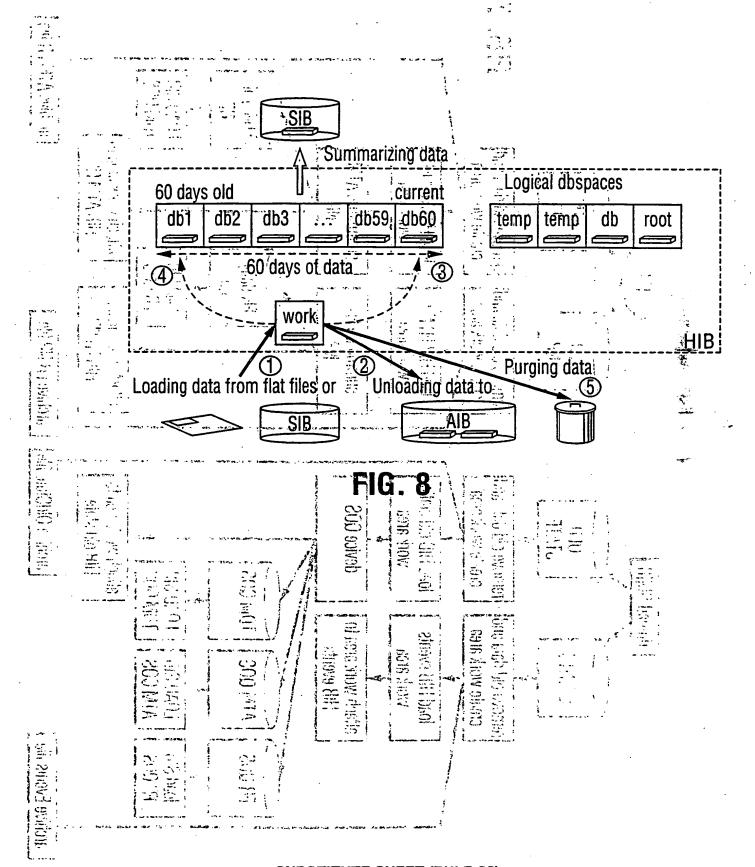
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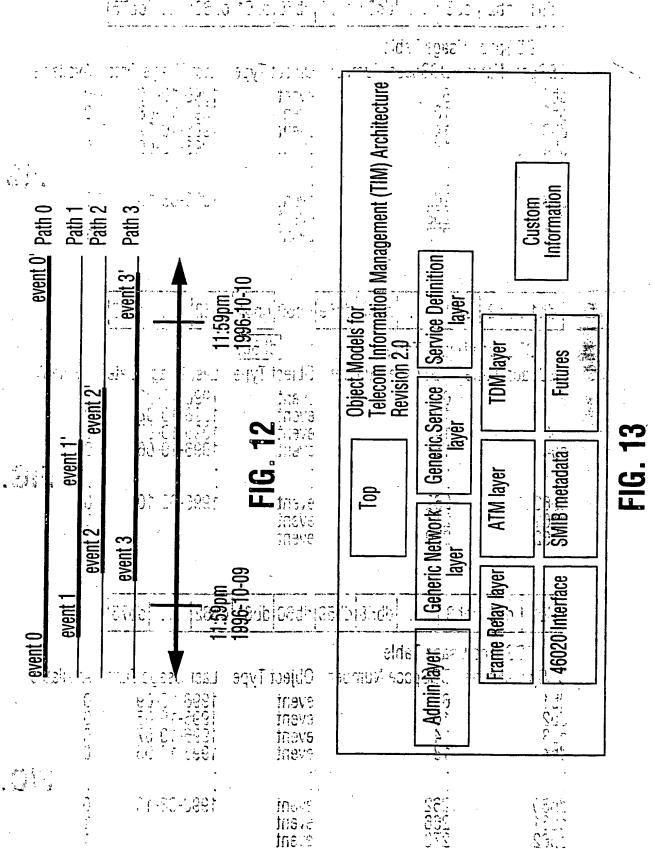


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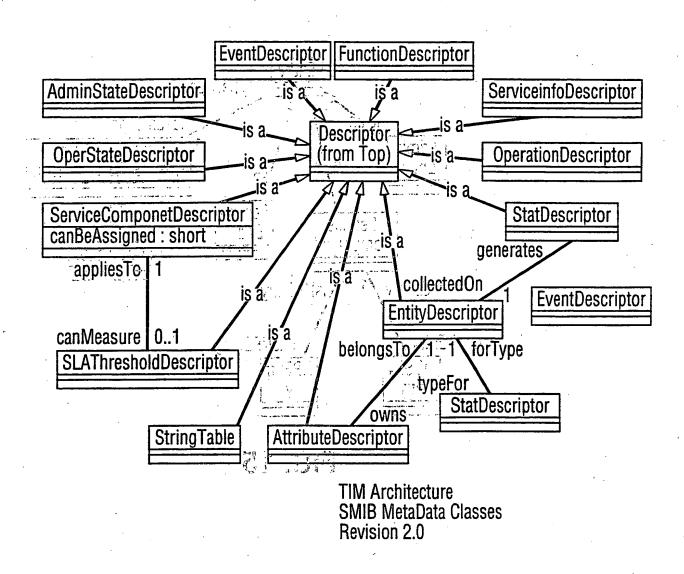
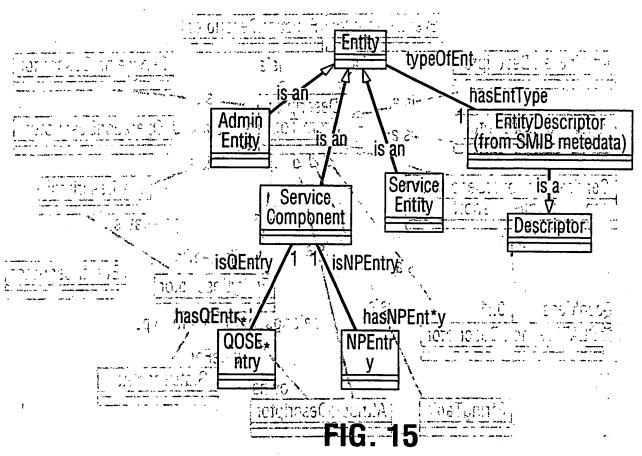




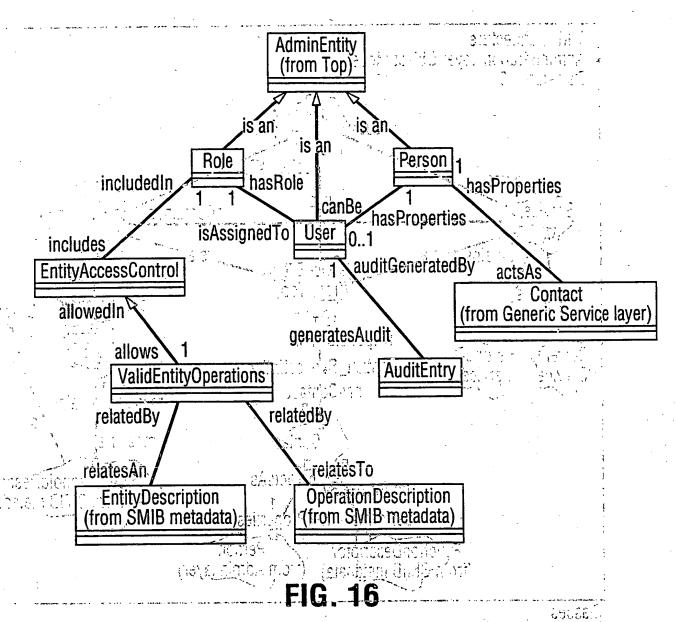
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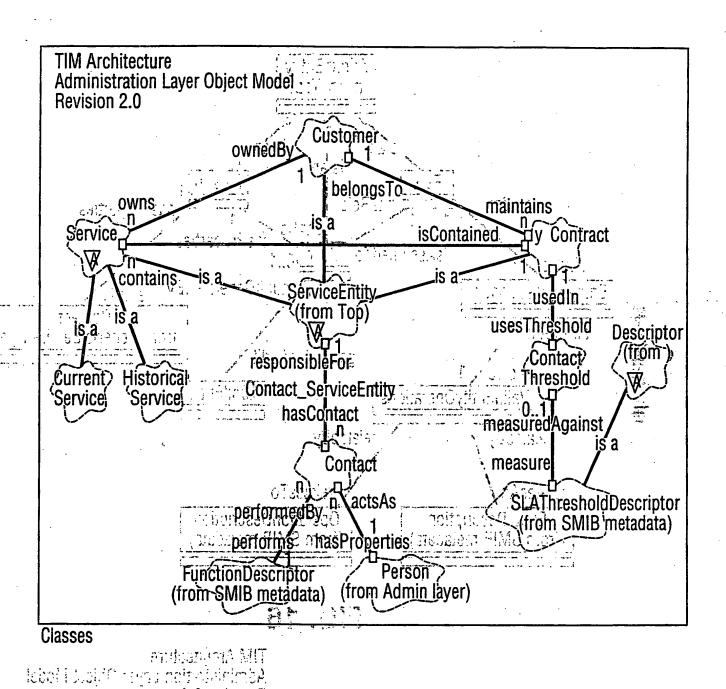


FIG. 17

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	March 1996 see page 6, line 7 - line 10 see page 14, line 18 - page 1 see page 30, line 14 - page 3		1
Α '	WO 96 26588 A (CALBETRON SYST August 1996	·	1-14
	see page 2, line 18 - page 2, see page 4, line 30 - page 5, see page 8, line 26 - page 9,	line 6	
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•	European Patent Office. P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,	Gregori, S	
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